APPENDIX B

Safety and Operation
(Codes and Manuals)

Note: Operation manuals are provided as a guide. Individual facilities should modify the enclosed information to meet their facility needs.

B.1, Radiation Safety Requirements for Analytical X-Ray Equipment – Florida Administrative Code

B.2, Use of XRF Analyzer

B.3, Handheld XRF Safety Manual

B.4, Field Safety Manual

B.5, Stationary (QXR-W) XRF Safety Manual

B.6, QXR-W XRF User Manual

B.7, FIELD SAFETY PRACTICIES

Appendix B.1, Radiation Safety Requirements for Analytical X-Ray Equipment – Florida Administrative Code

PART VII

RADIATION SAFETY REQUIREMENTS FOR ANALYTICAL X-RAY EQUIPMENT

64E-5.701 Equipment Requirements.

(1) Safety Device. A device which prevents the entry of any portion of an individual's body into the primary x-ray beam path or which causes the beam to be shut off upon entry into its path shall be provided on all open-beam configurations. A registrant may apply to the department for an exemption from the requirement of a safety device. Such application shall include:

(a) A description of the various safety devices that have been evaluated;

(b) The reason each of these devices cannot be used; and

(c) A description of the alternative methods that will be employed to minimize the possibility of an accidental exposure, including procedures to assure that the operator and others in the area will be informed of the absence of safety devices.

(2) Warning Devices.

(a) Open-beam configurations shall be provided with a readily discernible indication of:

1. X-ray tube on-off status located near the radiation source housing, if the primary beam is controlled in this manner; or

2. Shutter open-closed status located near each port on the radiation source housing, if the primary beam is controlled in this manner.

(b) Warning devices shall be labeled so that their purpose is easily identified.

(c) Warning devices shall have fail-safe characteristics.

(3) Ports. Unused ports on radiation source housings shall be secured in the closed position in a manner which will prevent inadvertent opening.

(4) Labeling. All analytical x-ray equipment shall be labeled with a readily discernible sign or signs bearing the radiation symbol and the words:

(a) "CAUTION - HIGH INTENSITY X-RAY BEAM", or words having a similar intent, on the x-ray source housing; and

(b) "CAUTION RADIATION -- THIS EQUIPMENT PRODUCES RADIATION WHEN ENERGIZED", or words having a similar intent, near any switch that energizes an x-ray tube if the radiation source is an x-ray tube.

(5) Shutters. On open-beam configurations, each port on the radiation source housing shall be equipped with a shutter that cannot be opened unless a collimator or a coupling has been connected to the port.

(6) Warning Lights. An easily visible warning light labeled with the words "X-RAY ON", or words having a similar intent, having fail-safe characteristics, shall be located near any switch that energizes an x-ray tube and shall be illuminated only when the tube is energized.

(7) Radiation Source Housing. Each x-ray tube housing installed after the effective date of these regulations shall be so constructed that, with all shutters closed, the leakage radiation measured at a distance of 5 cm from its surface is not capable of producing a dose in excess of 2.5 mrem (0.025 mSv) in any given hour at any specified tube rating.

(8) Each x-ray generator shall be supplied with a protective cabinet which limits leakage radiation measured at a distance of 5 cm from its surface such that it is not capable of producing a dose in excess of 0.25 mrem (2.5 uSv) in any given hour.

ecific Authority: 404.051, 404.141, 404.22, F.S.
v Implemented: 404.051(1)(4)(6), 404.141, 404.22, F.S.
tory: New July 17, 1985, Formerly 10D-91.803.

64E-5.702 Area Requirements.

(1) Radiation Levels. The local components of an analytical x-ray system shall be located and arranged and shall include sufficient shielding or have access control such that no radiation levels exist in any area surrounding the local component group which could result in a dose to an individual present therein in excess of the dose limits given in 64E-5.312. For systems utilizing x-ray tubes, these levels shall be met at any specified tube rating.

(2) Surveys.

(a) Radiation surveys, as required by 64E-5.314, of all analytical x-ray systems sufficient to show compliance with (1), above, shall be performed:

1. Upon installation of the equipment and at least once every 12 months thereafter;

2. Following any change in the initial arrangement, number or type of local components in the system;

3. Following any maintenance requiring the disassembly or removal of a local component of the system;

4. During the performance of maintenance and alignment procedures if the procedures require the presence of a primary x-ray beam when any local component in the system is disassembled or removed;

5. Any time a visual inspection of the local components of the system reveals an abnormal condition; and

6. Whenever personnel monitoring devices show a significant increase over the previous monitoring period or the readings are approaching the limits specified in 64E-5.312.

(b) Radiation survey measurements shall not be required if a registrant can demonstrate compliance with (1), above, to the satisfaction of the department.

(3) Posting. Each area or room containing analytical x-ray equipment shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words "CAUTION -- X-RAY EQUIPMENT", or words having a similar intent.

Specific Authority: 404.051, 404.141, 404.22, F.S.
Law Implemented: 404.051(1)(4)(6), 404.141, 404.22, F.S.
History: New July 17, 1985, Amended January 1, 1994, Formerly 10D-91.804.

64E-5.703 Operating Requirements.

(1) Procedures. Normal operating procedures shall be written and available to all analytical x-ray equipment workers. No individual shall be permitted to operate analytical x-ray equipment in any manner other than that specified in the procedures unless such individual has obtained the written approval of the radiation safety officer.

(2) Bypassing. No individual shall bypass a safety device or interlock unless such individual has obtained the written approval of the radiation safety officer. Such approval shall be for a specified period of time. When a safety device or interlock has been bypassed, a readily discernible sign bearing the words "SAFETY DEVICE NOT WORKING", or words having a similar intent, shall be placed on the radiation source housing.

(3) Repair or Modification of X-ray Tube Systems. Except as specified in (2), above, no operation involving removal of covers, shielding materials or tube housings or modifications to shutters, collimators or beam stops shall be performed without first ascertaining that the tube is off and will remain off until safe conditions have been restored. The main switch, rather than interlocks, shall be used for routine shutdown in preparation for repairs.

Specific Authority: 404.051, 404.081, 404.22, F.S.
Law Implemented: 404.051(1)(4)(6), 404.081(1), 404.22, F.S.
History: New July 17, 1985, Formerly 10D-91.805.

64E-5.704 Personnel Requirements.

(1) Instruction. No person shall be permitted to operate or maintain analytical x-ray equipment unless such person has received instruction in and demonstrated competence as to:

(a) Identification of radiation hazards associated with the use of the equipment;

(b) Significance of the various radiation warning and safety devices incorporated into the equipment, or the reasons they have not been installed on certain pieces of equipment and the extra precautions required in such cases;

(c) Proper operating procedures for the equipment;

(d) Symptoms of an acute localized overexposure; and

(e) Proper procedures for reporting an actual or suspected overexposure.

(2) Personnel Monitoring.

(a) Finger or wrist dosimetric devices shall be provided to and shall be used by:

1. Analytical x-ray equipment workers using systems having an open-beam configuration and not equipped with a safety device; and

2. Personnel maintaining analytical x-ray equipment, if the maintenance procedures require the presence of a primary x-ray beam when any local component in the analytical x-ray system is disassembled or removed.

(b) Reported dose values shall not be used for the purpose of determining compliance with 64E-5.304 unless evaluated by a qualified person, as defined in 64E-5.501(61).

Specific Authority: 04.051, 404.22, F.S.
Law Implemented: 404.051(1)(4), 404.22, F.S.
History: New July 17, 1985, Amended January 1, 1994, Formerly 10D-91.806.

Appendix B.2, Use of handheld XRF analyzer

Basic Instructions for Making a Measurement Using the Innov-X XRF Analyzer

1. Make sure that the standardization clip is attached to the front of the unit. Turn on power to the XRF (power button located at the rear of the device) and the power to the iPAQ (silver button on top right of iPAQ).

2. Next start the Innov-X software. Tap start (top left of iPAQ screen) and then tap Innov-X when the start menu opens (this is a square blue icon with a large white "X"). Tap "start" when the notice screen appears.

3. The Innov-X software will now load. The screen that appears will have two choices. Tap on "Soil".

4. The XRF will now begin to initialize itself. This may take a minute.

5. Once the XRF has initialized it must standardize. To do this tap the gray box on the iPAQ screen. The standardization takes about a minute. Once the standardization is complete a message will appear on the screen of the iPAQ indicating that it was successful. Tap the 'ok" on the top right of this message window to remove it. Remove clip if standardization was successful.

    a. If the standardization is not completed successfully try the following:
        i. Make sure that the standardization clip is attached properly. It should click into place.
        ii. Make sure the battery has a good charge. It may need to be changed. It pulls right out of the handle very easily and the charged battery only fits in one way so it can't be placed in wrong.
        iii. If battery is charged and the clip is placed on correctly and it will not standardize try restarting the system (Steps 9 – 11).
        iv. If it will still not standardize then it is broken.

6. Now the XRF is ready to perform the analysis. Press the unit against the sample and hold down the trigger. Once the trigger is released the XRF will stop performing the analysis. If the trigger is released in less than two seconds the analysis will be cancelled. After five seconds the analysis will automatically stop. (Refer to XRF Safety Manual for Proper Configurations for Use).

7. The results page will now appear. This will show what and how much the XRF has detected in the analysis. The results page can be closed by tapping the "X" on the top right of the iPAQ screen. You can either compress the trigger to perform another analysis from the results window or close it, either way the data is saved.

8. Once the analysis is complete the program must be turned off before turning off the power. Since the results are saved automatically, close the results window if it is open.

9. Next tap “File” at the bottom left of the iPAQ screen then choose “Exit”.

10. Now the original Innov-X screen will appear. Tap “File” and “Exit” again.

11. The regular iPAQ screen will now appear. Turn off the iPAQ and XRF unit.

Please refer to Innov-X XRF Operations Manual to download data from the IPAQ and for instructions for regular maintenance items (e.g. charging of batteries).

Appendix B.3, Handheld XRF Safety Manual

Overview and Proper Use of Handheld XRF (for more details please refer to radiation safety document provided by Innov-X)

The handheld XRF units emit x-rays in order to analyze test materials. The x-rays are emitted from the lens (sampling window) of the XRF in the form of a focused beam. The standard operating conditions for the tube inside the unit are a voltage of 35 kV, a current of 5 uA, and 2 mm of aluminum filtration. The radiation levels emitted from the beam under the standard operation conditions are as follows: less than 0.05 mrem/hr for the trigger of the unit or any part of the body, 28,160 mrem/hr at the sampling window, 2,080 mrem/hr 4 inches away from the sampling window, 186 mrem/hr 12 inches away from the sampling window, 24 mrem/hr 36 inches from the sampling window, and 14 mrem/hr 48 inches from the sampling window.

The x-rays emitted from the XRF are capable of passing straight through many different materials (such as wood) without loosing strength. Therefore it is very important to be mindful of where the device is aiming whenever performing an analysis. The beam is capable of passing through the sample material and tables upon which the samples are placed. A small amount of the X-rays are scattered back towards the unit. Therefore it is important to keep hands away from the sample window and the metal frontal portion of the unit.

Proper use includes holding the units by the handle and analyzing materials only when they are lying on the floor or a table (Figure B.5). The devices should never be used to analyze material that is being held in a person's hand. Always be certain that the beam is not pointed at anyone and assume that the beam may pass through testing material and any table the testing material upon which it is placed.

Radiation badges are recommended for individuals at a facility who will be using the XRF units on a day-to-day basis. According to Innov-X some states require the use of radiation badges. Innov-X also recommends that XRF operators wear badges, at least for the first year of operation, as a general precaution in case of misuse of the instrument.

Additional Safety Features

The XRF units themselves have some built in safety features to protect against accidental exposure. The first safety feature is a proximity sensor which stops the analysis if the unit is analyzing a sample and it detects that no sample is present. Therefore, if the units are activated while pointed aimlessly into the air the x-rays will stop emitting within two seconds. This reduces the risk of exposure with an open beam. The second feature is the deadman trigger. This feature makes the operator hold down the trigger while the test is being performed. When the trigger is released the x-rays will immediately stop emitting from the units. The third feature is a software trigger lock. The operator must manually turn this feature off before the x-rays can be emitted. It will also automatically reengage if not used for a period of time.

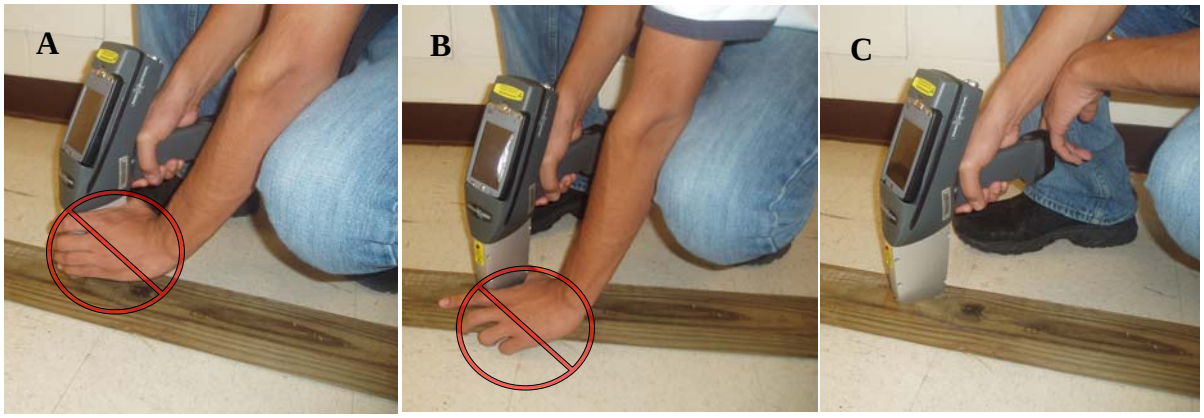

Figure B.5: Incorrect Ways to Hold the Hand-Held XRF Unit (Photos A and B) and Correct Way to Hold XRF Unit (Photo C)

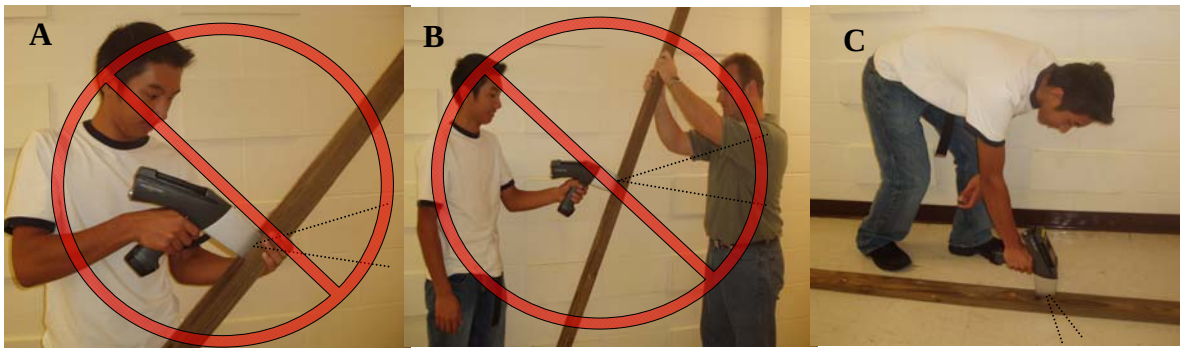

Figure B.6: Incorrect Ways to Position the Hand-Held XRF Unit (Photos A and B) and Correct Position the XRF Unit (Photo C). Lines in the figures show the predominant direction of the X-Rays.

Appendix B.4, Field Safety Information

Below is general safety information which can be used as a guide to supplement a facilities general operating safety manual.

General Safety Instructions

- Researchers are to report to the office immediately upon arrival to the facility in order to let the employees know of their presence at the facility. This will enable those who operate heavy equipment to know of their presence.
- Researchers should limit their activities to the area designated by the facility.
- Researchers should try to stay as a group while on the site.

Safety Apparel

- All researchers will be given the following, which should be worn at all times while on the site:
    - Hard Hat
    - Safety Goggles. If PAN indicator comes in contact with eyes, flush eyes with water in accordance with instructions on MSDS sheet.
    - Bright Vest with Convenient Pockets
    - Steel Toed Boots
    - Gloves. Use workman type gloves when handling wood
- Other Clothing Guidelines
    - While on site all researchers should wear long pants such as denim jeans.
    - There should be no loose clothing or jewelry dangling from the body. This could cause body parts to be pulled into machines such as the conveyer.
    - Hair should also be pulled back.
    - Any safety equipment that is not working properly or malfunctioning should be reported at once.

Equipment Safety

- XRF units
    - These devices should never be pointed at people. While in use they should only be pointed at samples being tested. Refer to XRF safety document in prior appendix and to radiation safety information provided by instrument manufacturer.
    - The XRF devices are somewhat fragile. While using them caution is required to insure that they are not dropped or bumped into other things.
    - Once the XRF devices are no longer being used for the day they should be locked up in the office.

- Equipment in general
    - Most of the equipment is valuable and possibly fragile.
    - All of the equipment must be safely locked up in the office on site or brought back to the lab and locked up safely.
    - Equipment is not to be left in vehicles or left outside without supervision.
    - If any equipment appears to not be working correctly or malfunctioning supervisor should be alerted at once.

Appendix B.5, Stationary (QXR-W) XRF Safety Manual

QXR-W
XRF SAFETY MANUAL

PREPARED BY: JOHN SCHINDLER & DR. HELENA SOLO – GABRIELE

THE MAJORITY OF THE INFORMATION INCLUDED
IN THIS DOCUMENT WAS OBTAINED FROM AUSTIN AI, INC.

UNIVERSITY OF Miami

COLLEGE OF ENGINEERING
CIVIL, ARCHITECTURAL & ENVIRONMENTAL DEPARTMENT

- September 2006 -

<u>NOTE</u>: OPERATING MANUALS ARE PROVIDED AS A GUIDE. INDIVIDUAL FACILITIES SHOULD MODIFY THE ENCLOSED INFORMATION TO MEET THEIR FACILITY NEEDS.

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XRF Safety Manual with Operating Instructions

Overview and Proper Use of Handheld XRF

The QXR-W emits x-rays in order to analyze test materials. The x-rays are emitted from the x-ray tube in the form of a cone shaped beam. The maximum operating conditions for the tube inside the unit are a voltage of 50 kV, a current of 1000 uA, and 2 mm of aluminum filtration.

The radiation levels emitted from the beam under the standard operation conditions are less than 0.05 mrem/hr at the surface of the instrument housing, and 0.05 mrem/hr at each sample opening (example: incoming material opening, and opening allowing materials exiting to diverter).

The x-rays emitted from the XRF are capable of passing straight through many different materials (such as wood) without loosing strength. Therefore it is very important for operators and employees to be mindful to keep hands away from the entrance and exits of the x-ray housing, where x-rays have the potential to scatter.

Proper use includes analyzing materials only when they are in free fall through the material delivery chute. The devices should never be used to analyze material that is being held in a person's hand, or any non-wood or wood bearing materials.

Radiation badges are recommended for individuals at a facility who will be using the XRF units on a day-to-day basis. According to Austin AI some states require the use of radiation badges. Austin AI also recommends that XRF operators wear badges, at least for the first year of operation, as a general precaution in case of misuse of the instrument.

Important Safety Information

The safe and proper operation of the Austin AI XRF instrument is the highest priority. These instruments produce ionizing radiation and should ONLY be operated by individuals, who have been trained by Austin AI and received a manufacturer's training certificate. Austin AI recommends that operators and companies implement a written Radiation Safety Program, with safety components specific to the site and application of use of the instrument. The Radiation Safety Program should be reviewed annually and revised appropriately by a competent individual.

Austin AI XRF analyzers must be used by trained operators, according to the instructions presented in this manual. Improper usage may circumvent safety protections and could potentially cause harm to the user. Pay attention to all warning labels and messages.

General Safety Precautions and Information

Retain and follow all product safety and operating instructions. Observe all warnings on the product and in the operating instructions. To reduce the risk of bodily injury, electric shock, fire and damage to the equipment, observe the following precautions:

Heed service markings. Except as explained in this documentation, do not service any Austin AI product yourself. Opening or removing covers may expose you to electric shock. Service needed on components inside these compartments should be done only by Austin AI authorized personnel.

Damage requiring service:

- The power cord, plug or battery contacts for the battery charger are damaged.
- Liquid has been spilled or an object has fallen onto the instrument.
- The instrument has been physically damaged.
- There are noticeable signs of overheating.
- The instrument does not operate normally when you follow operating instructions.

Safety Precautions:

Use the correct external power source: Ensure that the voltage is appropriate (100V-240 V/ 50-60 Hz) for the system. Do not overload an electrical outlet, power strip, or convenience receptacle. Do not pull on cords and cables. When unplugging the cord form the electrical outlet, grasp and pull the cord by the plug.

Austin AI – Recommended Radiation Safety Training Components

Individual Companies and States have specific regulations and guidelines for the use of X-ray tube generated ionizing radiation. The purpose of the recommendations below is to provide generic guidance for an ALARA - best practice - approach to radiation safety. These recommendations do not replace the requirement to understand and comply with the specific policies of any state or organization.

1. **Proper Usage.** Never use the instrument to analyze another person. Never hold a sample in your hand and test that part of the sample.
2. **Establish Controlled Areas.** The location use should be of restricted or limited access to reduce potential exposure to ionizing radiation.
3. **Specific Controls.** The instrument's X-ray interlock key should be stored, in a locked case, or locked cabinets when not in use. When in use, it must remain in the direct control of a factory trained, certified operator.
4. **Time - Distance - Shielding Policies.** Operators should minimize the time around the energized instrument, and maximize the distance from the instrument window whenever possible.

5. **Prevent Exposure to Ionizing Radiation.** All reasonable measures, including labeling, operator training and certification, and the concepts of time, distance, & shielding, should be implemented to limit radiation exposure to as low as reasonably achievable (ALARA).
6. **Personal Monitoring.** Radiation control regulations may require implementation of a radiation monitoring program, where each instrument operator wears a film badge or TLD detector for an initial period of 1 year to establish a baseline exposure record. Continuing radiation monitoring after this period is recommended, but may be discontinued if accepted by radiation control regulators.

Additional Safety Features

The XRF units themselves have built in safety features to protect against accidental exposure. The Austin AI's QXR-W is very safe when used correctly, however the analyzer does emit radiation through the analyzer window, and all precautions must be taken to reduce exposure to this radiation. In order to minimize the possibility of accidental exposure, the following safety features are standard in all Austin AI systems:

1. **Safety Interlock Switches, Trip Redundancy.** The power to the x-ray tube is only available when all safety interlocks (shielding panels) are in place, an interlock key is thrown and an X-ray "on" button is pressed. This requires that the user consciously enable x-rays, allowing them to be emitted.

2. **X-ray Indicator Light.** A red light is illuminated when X-rays are emitted by the system; indicating to the users that safety precautions are in effect.

3. **"Emergency Off" Button.** An emergency off button shuts down power to the X-ray tube, which can only be restarted via re-enabling the interlock key.

Performing a Test Following Appropriate Radiation Safety Procedures

Starting the Analyzer:

The X-ray tube is controlled by voltages adjusted by potentiometers (pots) on a panel inside the computer enclosure. Settings and monitor voltages can be measured by connecting a voltmeter to the jacks on the panel. The scales are:

Voltage

- 0 to 10 VDC indicates 0 to 50,000 V (50 kV) on tube. 50 kV is the maximum allowed. The nominal setting is 45 kV (9V on monitor)

Current

- 0 to 10 VDC indicates 0 to 1,000 micro amp (µA). 950 µA (9.5 V on monitor) is the nominal setting.

If the tube has been unused for one week or more, start it slowly, with this schedule:

1. Turn the current all the way to 0.

12. Turn the voltage to 10 kV (2 volts on the test point).

13. Raise the current to 100 µA (1 volt on the test point). Wait 5 minutes.

14. Raise the voltage to 20 kV (4 volts on the monitor). Wait 5 minutes.

15. Raise the voltage to 30 kV (6 volts on the monitor). Wait 5 minutes.

16. Raise the voltage to 40 kV (8 volts on the monitor). Wait 5 minutes.

17. Raise the voltage to 50 kV (10 volts on the monitor). Wait 5 minutes.

18. Raise the current to 250 µA (2.5 volts on the monitor).

19. Wait 5 minutes, then increase current by 100 µA. Repeat until desired operating current is reached, then adjust HV if necessary.

Operating the Program

Routine, when the system is pre-configured:

1. Check the X-ray tube settings.

2. Double-click the XRC icon on the desktop.

3. On the menu, choose “File, Open Process” and select the configuration file.

4. On the menu, choose “View, Settings, General” and make sure that the triggering device is properly selected. (Video or Com Port). If video is selected, choose “View, Settings, Video Card” and confirm that the source is “Composite” and that the triggering sensitivity and set point are still set correctly.

5. Close this box, then on the menu select “View, Pre-processing”. Put a known sample in front of the viewing window using tape to suspend the piece. Click and hold the “Test Scan” button on the screen for about 1 second, then release. You should see a spectrum in the window, and at the bottom of the box, near the text “Values found”, will be the identifications of the parts.

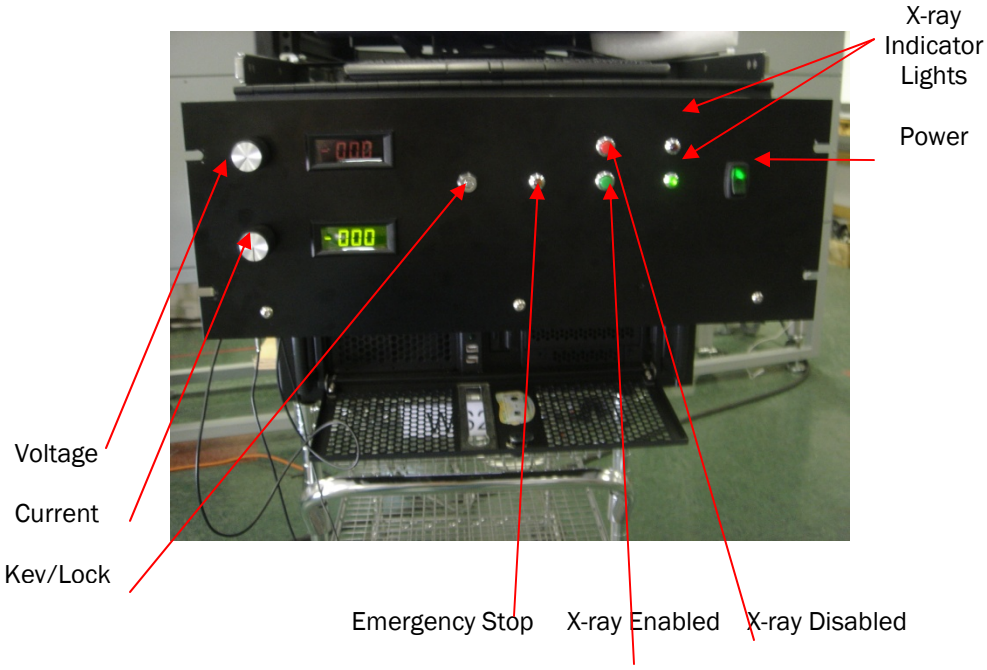
6. Try some other parts. If all works well, close this window and click the “Stand By” button in the upper right of the main window. The “Recycling” icon should now be animated. Use the material chute to deliver samples and begin sorting.

Radiation Warning Lights And Labeling

Main Power switch and Indicator Light:

It is necessary to also power on the X-ray tube via an additional power switch on the front of the control panel. The X-ray key must be present, and thrown for the X-ray tube to function. When thrown, the yellow caution LED is lit indicating X-rays are enabled but are not necessarily on. Manual adjustment knobs are used to dial in the desired current and voltage settings of the X-ray tube.

The red button allows X-ray function. When depressed, the red warning LED is illuminated and X-rays are emitted. The green button is the X-ray stop button. When depressed, the X-rays are turned off and a green LED is illuminated indicating a safe environment.



X-ray Light and Control Switches:

The Austin AI QXR-W is equipped with warning lights that alert the operator when the tube is receiving power, and when x-rays are being emitted from the analyzer.

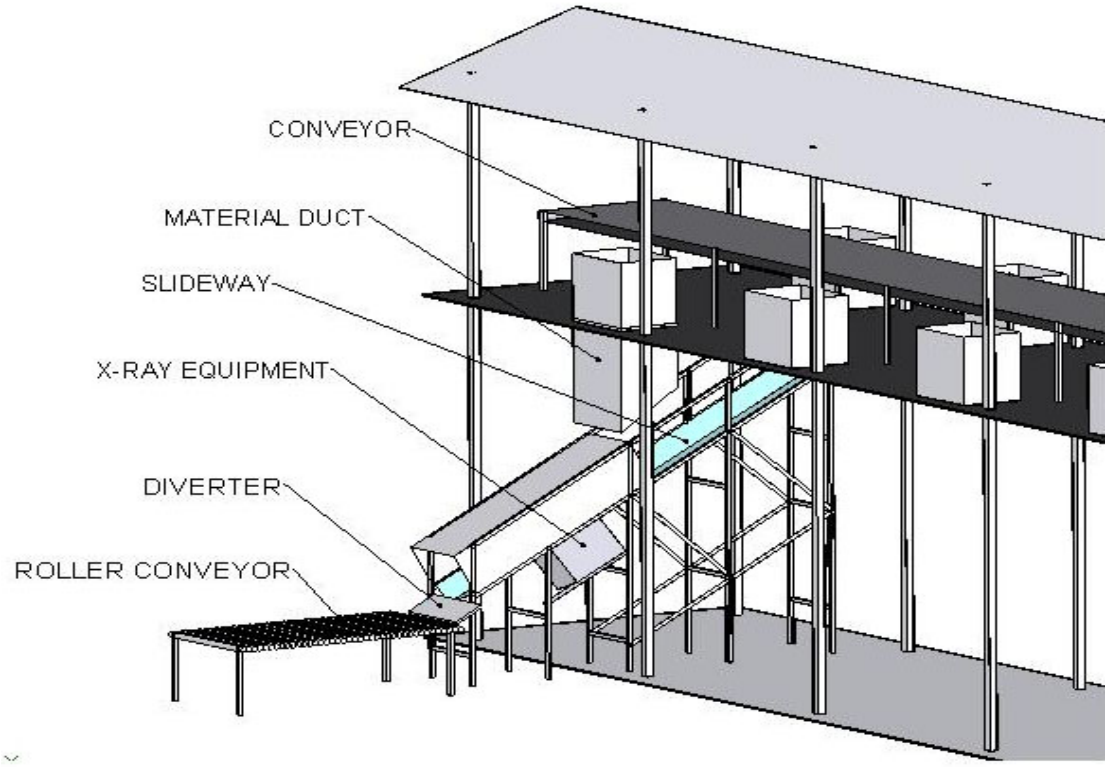
When the red light on the top of the analyzer is ON continuously, this indicates the x-ray tube is receiving a low level of electrical power emitting X-rays. The red/green buttons on the control panel (above) turn the x-rays on and off.

Labels:

The user is responsible for posting radiation labels on and around instrument area, as required by local regulatory agencies.

Radiation Levels from Analyzer

A schematic of the analyzer at the client's site is shown below. The measured radiation levels for standard operating conditions are shown in the figures and tables below. Standard operating conditions are tube voltage operating at 40 kV, tube current of 500 uA, and 2 mm aluminum filtration.



Position	1 –Duct Opening	2 – XRF Housing	3 – Diverter Opening
Rad (mRem/hr)	<=.05	<=.05	<=.05

Comparative: Radiation Doses from Typical Exposures to Ionizing Radiation

Common medical and/or dental x-rays:	20-30 mrem each.
Mammogram:	100-200 mrem
Flying in a commercial jet coast to coast (6 hrs.):	1-2 mrem.
Daily exposure from background radiation:*depends on geographic location	0.3 to 0.5 mrem/day

From the above table, a single case of analyzer misuse, thus producing a one-time exposure of 70-250 mrem, is comparable with single-event common medical x-ray procedures such as an annual chest x-ray or mammogram, or 25-50 airline flights in a year, and thus is not considered harmful. Regular misuse, such as taking safety shortcuts twice weekly, produces radiation exposure that greatly exceeds these typical levels and should be avoided entirely.

Safe Guards and Emergency Response

The main safeguards to use as an owner of an Austin AI QXR-W are really intended to restrict access to properly trained operators:

1. Keep the system in a controlled location, where only authorized users are likely to have access to the analyzer at any given time.

2. Make a simple sign that is kept with the analyzer indicating that an operator must have completed a training class provided by your company or must have attended an Austin AI training course in order to use the analyzer. Note that when the Austin AI QXR-W is turned on, the screen displays a message indicating that the system should only be used by authorized personnel.

Emergency Response:

Because the Austin AI QXR-W is a power operated, x-ray tube based analyzer; the emergency response plan is very simple. If the operator believes the analyzer is locked up in an "X-rays ON" condition, they should do two things:

1. Press the On/Off switch on the control panel to the off position. The X-rays On-Light will not be illuminated, indicating system power is off. At this point it is not possible for the analyzer to be producing x-rays.

Note: It would be highly unusual for an operator to somehow lock up the analyzer with the x-ray tube powered on. This would require the operator to modify or by-pass hardware safety features.

Dosimeter Badges

Dosimeter badges are provided as a monthly service by several companies, listed below. The badges are generally provided monthly, and the operator returns the previous month badges to the company for analysis. The operator receives a monthly report showing any personnel with readings higher than typical background radiation.

Dosimeter badges are required by some states, and optional by other states. Austin AI recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn on the belt loop or shirt pocket) and are available as "ring" badges. The best single badge to obtain is a ring badge that is worn on a finger, on the opposite hand used to hold the analyzer. This will record accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it. Note: these badges generally have a threshold of 10 mrem, and are renewed monthly. So it will take several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

Dosimeter Companies:
Here are two companies that provide badges as a regular service. There are certainly many more.

- **Landauer Inc**. Glenwood, IL
  Ph: 708-755-7000
- **AEIL.** Houston, TX
  Ph: 713-790-9719

Common Questions and Answers Regarding Radiation Safety

Question: When I'm analyzing wood, is there any exposure to people standing in other locations, or standing several feet away from the analyzer?

> *Answer:* Even a thin amount of lead shielding (1-2 mm thickness) is enough to completely attenuate the x-ray beam emitted from the Austin AI QXR-W. The analyzer is housed with shielded panels to prevent exposure, each of which are hardwired to safety interlock switches to prevent exposure should they be removed or improperly installed.

Question: Do I need to create restricted areas where the analyzer is in use?

> *Answer*: No, provided you are following normal operating procedures there is no reason to restrict access to an area where the analyzer is in use. The operator should take precautions to keep any personnel more

than 3 feet away from the conveyor line, to insure clearance for material exiting the QXR-W.

Question: How does the x-ray tube in the Austin AI system compare to a radiography system used for taking images of metal parts.

Answer: The x-ray tube used in the Austin AI system produces about 20 to 200 times lower power than most radiography systems (5-50 watt for Austin AI versus kW for radiography systems). This is because an analytical XRF is designed to perform surface analysis of alloys and other samples, whereas radiography systems are designed to shoot x-rays entirely through metal components in order to obtain an image on the other side of the object being bombarded with x-rays. For example, many tube-based radiography systems use a 300-400 kV tube and currents in the tens or hundreds of milliamps (mA). The Austin AI analyzer uses a tube operating at 50 kV and 1000 micro-amps. The radiation levels produced are therefore thousands or tens of thousands times lower with the Austin AI system.

Question: Should we use dosimeter badges with the Austin AI analyzer?

Answer: Dosimeter badges are required by some states, and optional by other states. Austin AI recommends that operators wear badges, at least for the first year of operation, as a general precaution to flag any misuse of the analyzer. Dosimeter badges are available for the torso (generally worn on the belt loop or shirt pocket) and are available as "ring" badges. The best single badge to obtain is a ring badge that is worn on a finger, on the opposite hand used to hold the analyzer. This will record accidental exposure for the most likely case – an operator grabbing a small sample and holding it in one hand while analyzing it. Note: these badges generally have a threshold of 10 mrem, and are renewed monthly. So it will take several cases of misuse even to obtain a reading on a typical badge. When purchasing a badge, obtain the type used for x-ray and low energy gamma ray radiation.

Typical Registration Requirements

Most states require some form of registration, and generally they require the registration to be received within 30 days of receipt of the instrument. Some states require no registration, while a few require notification in advance. Please contact Austin AI for specific questions regarding the state where the instrument will be used, or for copies of registration forms.

In general a company will have to provide the following information regarding the device:

1. Purpose of device. Generally this is "Analytical" or "Industrial." Be

sure to inform the state registration office that the device will NOT be used for radiography or for medical uses.

2. Radiation Safety Officer – Monitors training, safe use, and controls access to the instrument.

3. Authorized Users – Trained by Austin AI Factory Authorized Representatives in the safe and proper use of the XRF

4. Operating parameters of the analyzer – 50 kV, 1000 micro-amps.

5. Type of system, fixed, mobile or portable. Generally the correct choice is "Fixed."

6. User Training Specified – Indicate that only individuals receiving manufacturer training, documented by a manufacturer's training certificate will operate the instrument.

7. Personal Monitoring. This may be required by radiation control authorities. Many registration forms will ask that you indicate whether or not you intend to perform dosimeter monitoring.

8. Copy of Registration & Manual at the Job Site

If you have any questions regarding the type of registration form or filling out the form, please contact Austin AI. Many states may confuse XRF systems that use a tube with medical or industrial radiography systems. In all likelihood, Austin AI personnel have experience providing the necessary documentation to the state in question, and can readily assist the customer in this process.

QXR-W

User's Manual

Revision 2.0c
July 2008

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Read the User's Manual before operating the QXR-W system.

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1. General Description

The QXR-W is an Energy Dispersive X-ray Fluorescence (EDXRF) spectrometer used for non-destructive sorting and separation of wood contaminated with arsenic. Figure 1 shows the system assembled in the University of Miami test area at Florida Wood Recycling (FW) in Medley, Florida. This system is designed to receive wood on the right side of the long conveyor (as viewed from above, looking in the direction of wood flow). The treated wood will be rejected from the nominal flow from the long conveyor onto the inclined take-away conveyor.

Figure 1. QXR-W system in the University of Miami test area at FW.

The QXR-W system was designed for use in the western bay below the Erin Systems C&D sorting line. The C&D sorting line is shown in Figure 2 as viewed from the south. Figure 3 shows the bay as viewed from the north.

Figure 2. Erin Systems C&D sorting line at FW as viewed from the south.

Figure 3. The western bay of the sorting line as viewed from the north.

For the QXR-W to sort effectively, the wood must be on the a single layer stream of wood will fall from the Northern A-line drop chute and the B-line drop chute onto a conveyor that passes the wood under the QXR-W. If the system detects arsenic, the

diverter is signaled to rise, sending the pieces to a “reject” pile. If none of the named elements are detected, the diverter remains in the down position and the wood will fall onto the inclined take-away conveyor.

2. Installation in the C&D Sorting Bay

The bay is 13’ wide inside. The sides are lined with 6’ tall steel plating. The QXR-W is designed to be oriented with the inclined conveyor at the south end of the bay. The wall of the bay will need to be modified to allow the inclined conveyor with its wood flow to pass thru the wall. The conveyors should be positioned as shown in the document “QXR-W Conveyor Setup Rev A.pdf”. Portions of these drawings are shown in Figures 4 and 5. The drawings are not complete and are intended for specifying the recommended initial positioning of the conveyors relative to each other and the bay. The inclined conveyor should not extend into the adjacent bay, to avoid being hit by machines. The legs of the conveyors should be bolted to the concrete slab. The long conveyor should be fastened to the walls of the bay via steel angle or channel stock to stabilize it against loads such as men working and wind. Slides should be positioned below the drop chutes to direct wood flow onto the western half of the long conveyor belt or to the reject wood pile. The control panel should be positioned to avoid falling debris.

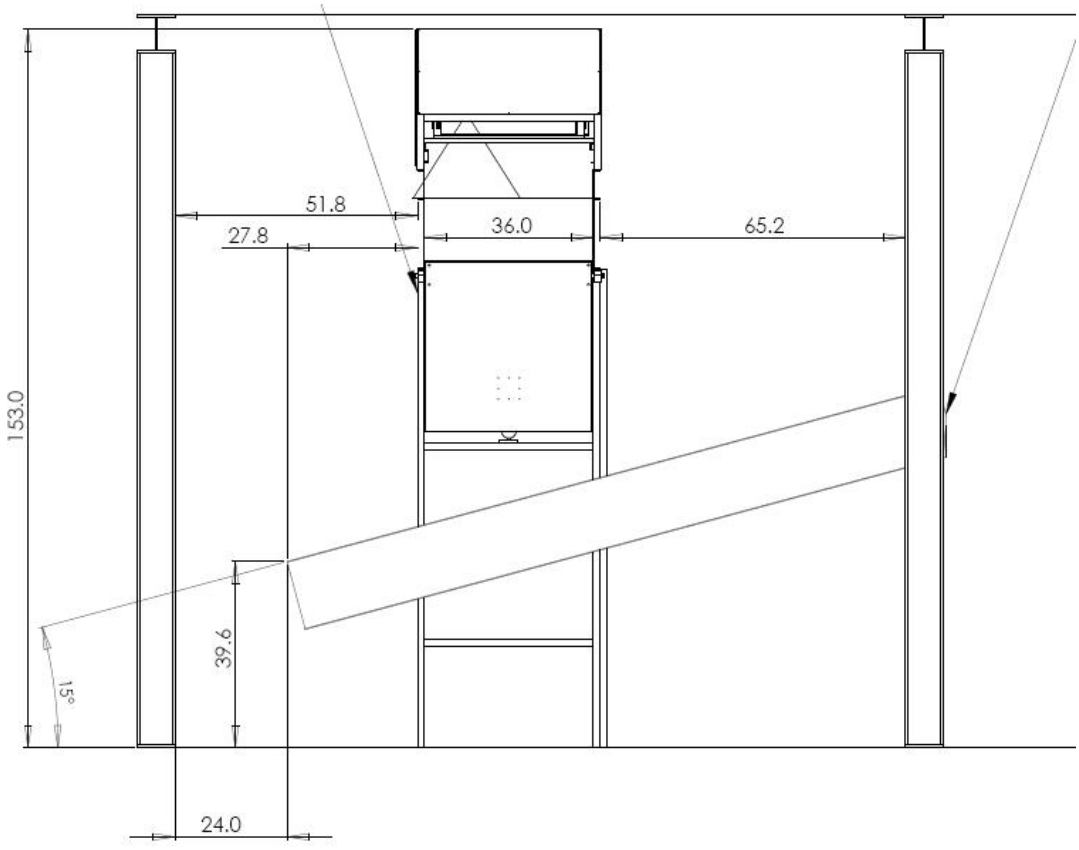


Figure 4. Portion of QXR-W Conveyor Setup Rev A.pdf, south view.

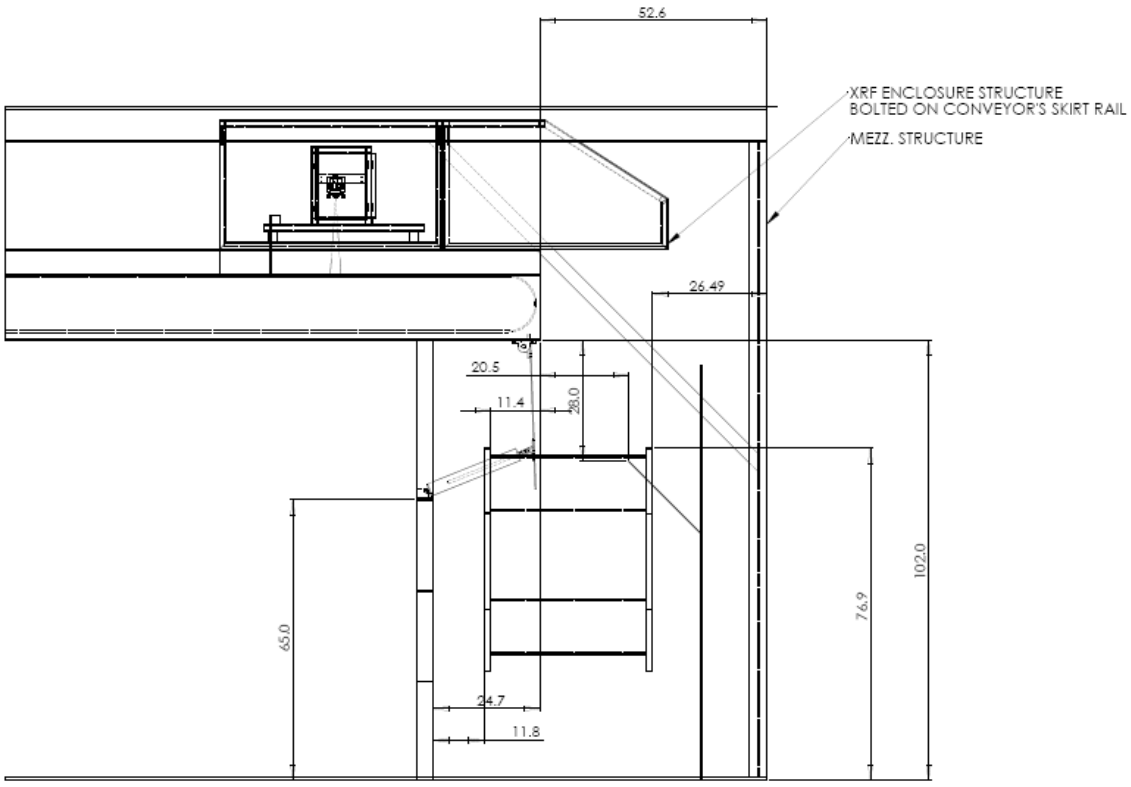


Figure 5. Portion of QXR-W Conveyor Setup Rev A.pdf, west view.

3. Installation in the U. of Miami Test Area

The QXR-W system was set up in the University of Miami test area at the Florida Wood Recycling site for testing prior to installation in the C&D sorting line bay. The legs of the conveyors are set up on top of treated 4x6 lumber, and the long conveyor is tied to large concrete blocks.

The inclined conveyor is positioned relative to the long conveyor in such as a way as to have good wood flow past the diverter plate and onto the inclined conveyor. The conduit to the inclined conveyor has additional length in a coil under the conveyor to allow for the conveyor to be moved without needing an electrician. The conduit to the inclined conveyor should be covered to prevent the potential electrical hazard.

The inclined conveyor should have metal sheets at its lower end to help contain wood on the belt. Some wood that falls on the belt may bounce off without the additional sheeting. The plates should be angled at approximately 45 degrees and not hinder wood flow to the rejected wood pile. Figure 6 shows the lower end of the inclined conveyor.

Figure 6. SE view of the system in the test area.

4. QXR-W Components

The QXR-W consists of the following major components: optical assembly, XRF box, shielding enclosure, long infeed conveyor, diverter, inclined take-away conveyor, and control console. The optical assembly is mounted in the XRF box. The XRF box is mounted on vibration isolator springs inside the shielding enclosure. The shielding enclosure is mounted to the discharge end of the long infeed conveyor. The diverter assembly is mounted beneath the discharge of the long conveyor. The take away conveyor lies below the discharge of the long conveyor.

Shielding Enclosure

The shielding enclosure is bolted to the long conveyor. It isolates the XRF box from wind and rain, and its steel panels contribute to the blocking of X-rays.

There is a safety switch on each of the two doors of the shielding enclosure.

Avoid touching the safety switches on the doors, as the actuators are easily damaged if pulled or pushed the wrong direction.

The top panel of the shielding enclosure should be caulked to prevent water entry.

Keep all the doors and panels of the shielding enclosure closed and properly fastened.

The entry point of the cabling into the shielding enclosure should be plugged with foam to prevent water entering the enclosure.

The leaded vinyl curtains are positioned to shield X-rays. If they are moved or repositioned, the system shielding should be checked by qualified personal.

Wood should not be loaded onto the long conveyor belt as to create a jam at the entrance of the shielding enclosure. If a jam occurs, stop the conveyors, turn off the system, remove the X-ray enable key, push the Emergency OFF button, and clear the jam. Wood jammed at the entrance to the shielding enclosure could damage the enclosure, vinyl curtains, and/or conveyor belt.

If the vinyl curtains are damaged they should be repaired and the system shielding should be checked by qualified personal.

There is lead sheeting bonded to the side of the conveyor's skirt rail, and on the underside of the bed of the long conveyor. This lead sheeting contributes to the blocking of X-rays.

If the lead sheeting is removed or damaged, it should be replaced, and the shielding of the system should be checked by qualified personal.

XRF Box

The XRF box houses the optical assembly, the high voltage power supply, and the digital processor for the X-ray detector (see Figure 7 and Figure 8). Its steel panels contribute to the blocking of X-rays. The bottom panel of the XRF box has a window that is transparent to X-rays but will keep the optics area clean.

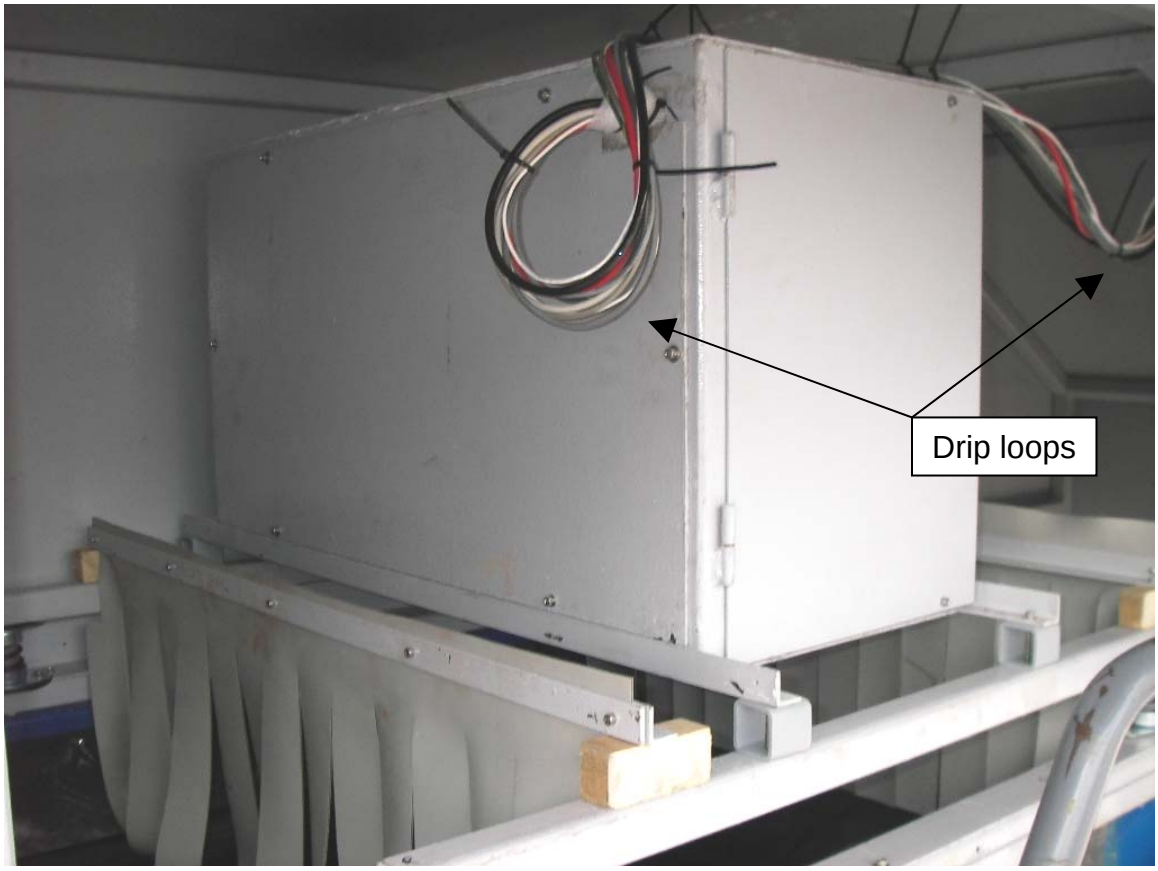


Figure 7. The exterior of the XRF box.

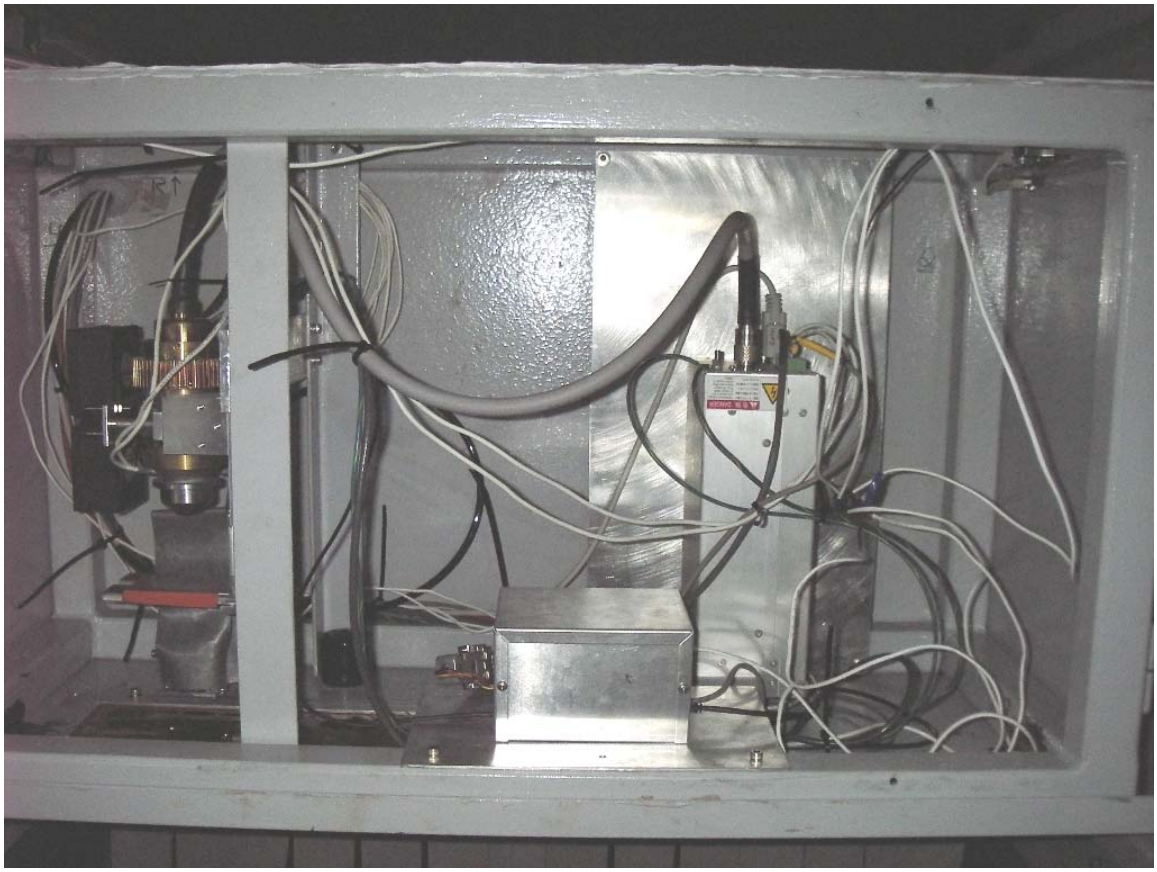


Figure 8. The inside of the XRF box as viewed from the discharge side.

There is a safety switch on each of the three doors of the box.

Act cautiously in the XRF box. The components, the wires, and their connectors should be handled gently. Avoid touching the safety switches on the doors, as the actuators are easily damaged if pulled or pushed the wrong direction.

Keep all the doors and panels of the XRF box closed and properly fastened.

The XRF box should be kept clean to minimize dust build up on the electronics and optical components. Do not leave the doors or panels open or window off to minimize dust infiltration.

The cabling into the XRF box should have drip loops, as well as the entry point should be plugged with foam to prevent water entering the box.

The top panel of the XRF box should be caulked to prevent water entry.

The XRF box is mounted on rails that are mounted on four spring isolators. The spring isolators are designed for vertical loads only. Do not push on the box – this will induce lateral forces on the spring isolators and they may break.

The interior leaded vinyl curtains are positioned to shield X-rays. If they are moved or repositioned, the system shielding should be checked by qualified personal.

Optical Assembly

The key components of the optical assembly are a detection system (detector) and an excitation system (X-ray tube). They are mounted together in the XRF box (see Figure 9).

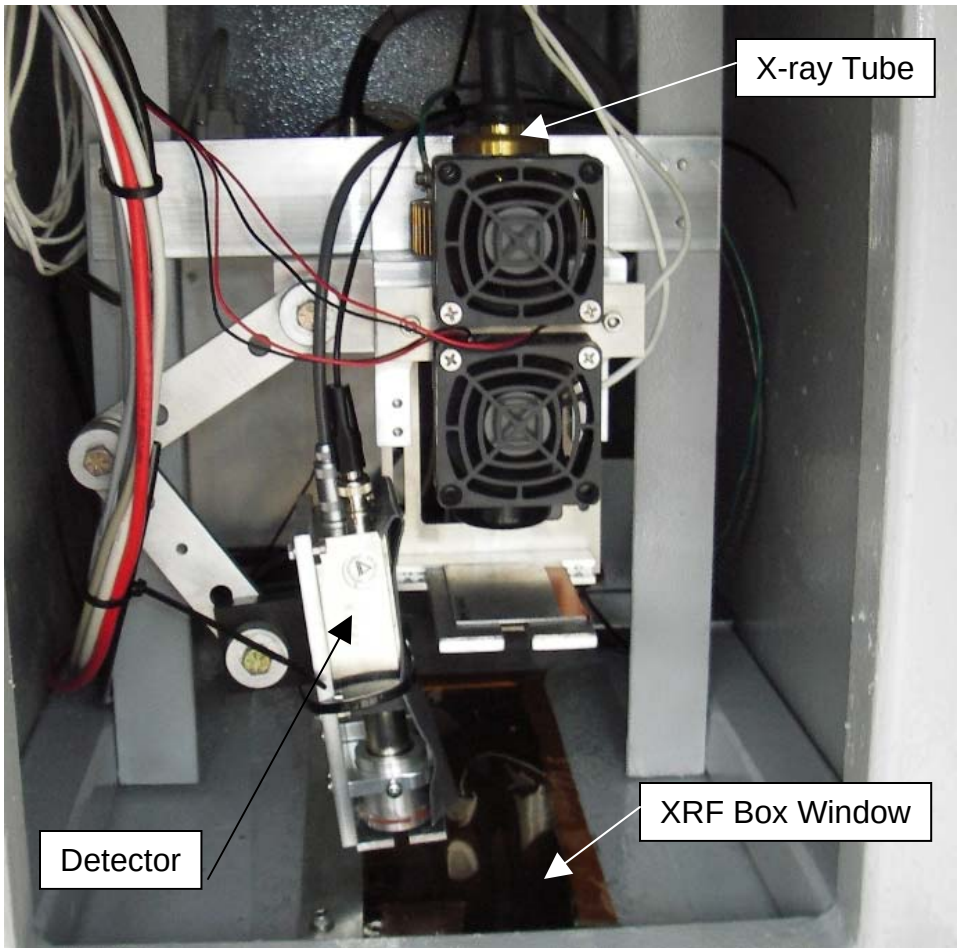


Figure 9. The optical assembly as mounted in the XRF box.

Act cautiously in the XRF box. The components, the wires, and their connectors should be handled gently.

Do not touch the end windows of the X-ray tube or detector. The windows are made of beryllium and are easily damaged.

The detector and tube are collimated their adjustment is sensitive. Adjustment of the collimation can result in a drop in performance and risks damaging the equipment.

The detector is mounted to a plastic piece in the arm to electrically isolate it. The detector should not touch the X-ray tube's collimator plates.

The XRF box window film is clamped and taped in place to hold the film and seal out dust.

Diverter

The diverter is mounted under the discharge end of the long conveyor (see Figure 10). The diverter plate pivots on a shaft and is actuated by a pneumatic cylinder. The pneumatic cylinder is controlled by a solenoid valve that receives an electric signal via wires from the control cabinet.

Figure 10. The diverter assembly is mounted to the long conveyor.

The diverter should be operated at low pressure to minimize risk of injury and the load on the hardware. It is recommended to operate at 45 psi, and no greater than 50psi.

The diverter can move without warning.

The emergency stops do not deactivate the diverter. It is only deactivated by removing the air supply. The air supply can be interrupted by the red exhaust valve next to the

regulator. The valve can be turned so it indicates “EXH”, and its dial allows it to be locked.

The air line from the valve to the base-end of the cylinder is short and large to allow for high air flow. The air line from the valve to the diverter plate end of the cylinder is longer and smaller to slow the return movement of the diverter relative to the extension movement.

The valve and regulator mounted close to the cylinder in order to have short tubing lengths. Once the diverter performance is confirmed adequate, it should be mounted rigidly to the legs.

> The quick-exhaust valves mounted on the cylinder allow for quicker movement. Their exhausts are routed thru short tubes that open downward to minimize water and dust infiltration into the valves.

Control Console

The control console is shown in Figure 11. The control console is the control panel and contains the electronics and purge pneumatics. The control panel is shown again in Figure 12. The control panel has an emergency stop button, the conveyor control keypads, the X-ray “ON” and “OFF” buttons and LED indicators, the X-ray “Enable” key and LED indicator, the system power switch, the computer’s keyboard and mouse, and the monitor window.

Figure 11. The control console at the U of Miami test area.

Figure 12 . QXR-W System control panel.

The control cabinet has four leveling feet to be adjusted for uneven surfaces.

The control cabinet and its wire entry should not be in standing water.

The top of the control cabinet should be covered and its doors locked to prevent water entry.

The interior lower access panel slides for variable sized wire entry. It should be slid shut to minimize dust infiltration.

The door and lid should be kept closed to minimize dust infiltration.

The enclosure purging pneumatics are resting in the bottom of the control cabinet. There is a filter/regulator unit that receives its supply of air on the filter side. The regulator should be set to the pressure which supplies adequate air to the enclosures – 5psi -15psi should be sufficient. The output is a 3-port manifold which has tubing going to the interior of the control cabinet, the interior of the conveyor motor control cabinet via the flexible conduit, and the interior of the XRF box. The flow of air to the XRF box is controlled by the regulator set pressure. The flows of air into the motor control box and the control cabinet are controlled by the small flow control valves near the manifold.

5. System Requirements

Air supply:
- Clean, dry air (moisture and oil removed)
- 18 scfm
- 90psi to 110psi

Power
- 120 VAC Single Phase, 5A sufficient (for control console)
- 460 VAC Three Phase, 10A suffieient (for conveyors)

Control Panel
- Covered from rain

Motor Control Enclosure
- Covered from rain

The system should not be in direct sunlight to avoid overheating.

6. Specifications

Control Console Electrical Supply
- 110 VAC, 5 Amp, 60 Hz
- 5 Amp fuse

X-ray tube and power supply
- Maximum 50 kV, 1 mA

7. Operating Software

A. AAI

Used for sorting, reads spectra, does calculations, and operates diverter.

Startup

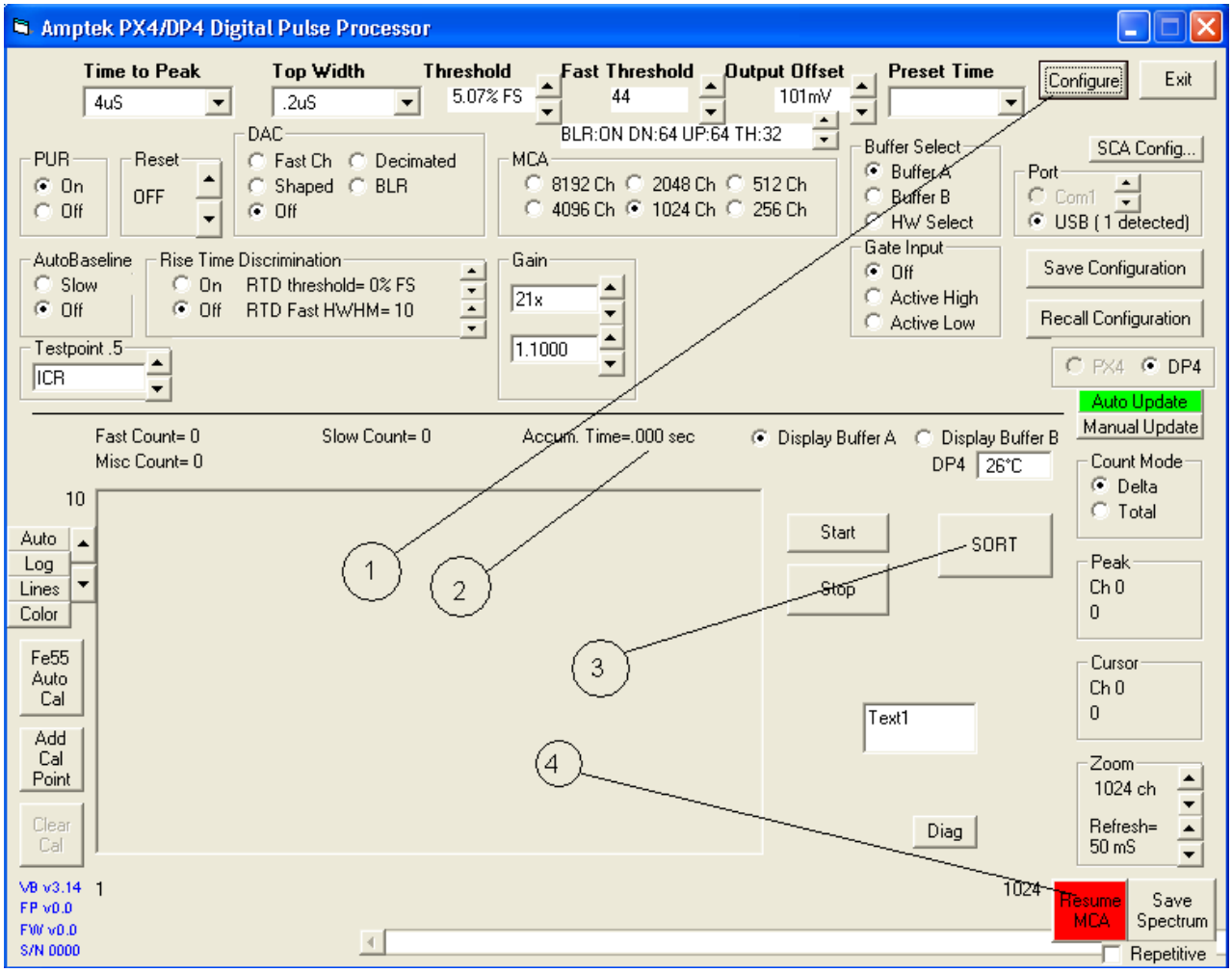
To start the software, click the icon labeled “AAI6 UoM.exe”. A screen similar to the one below will appear.

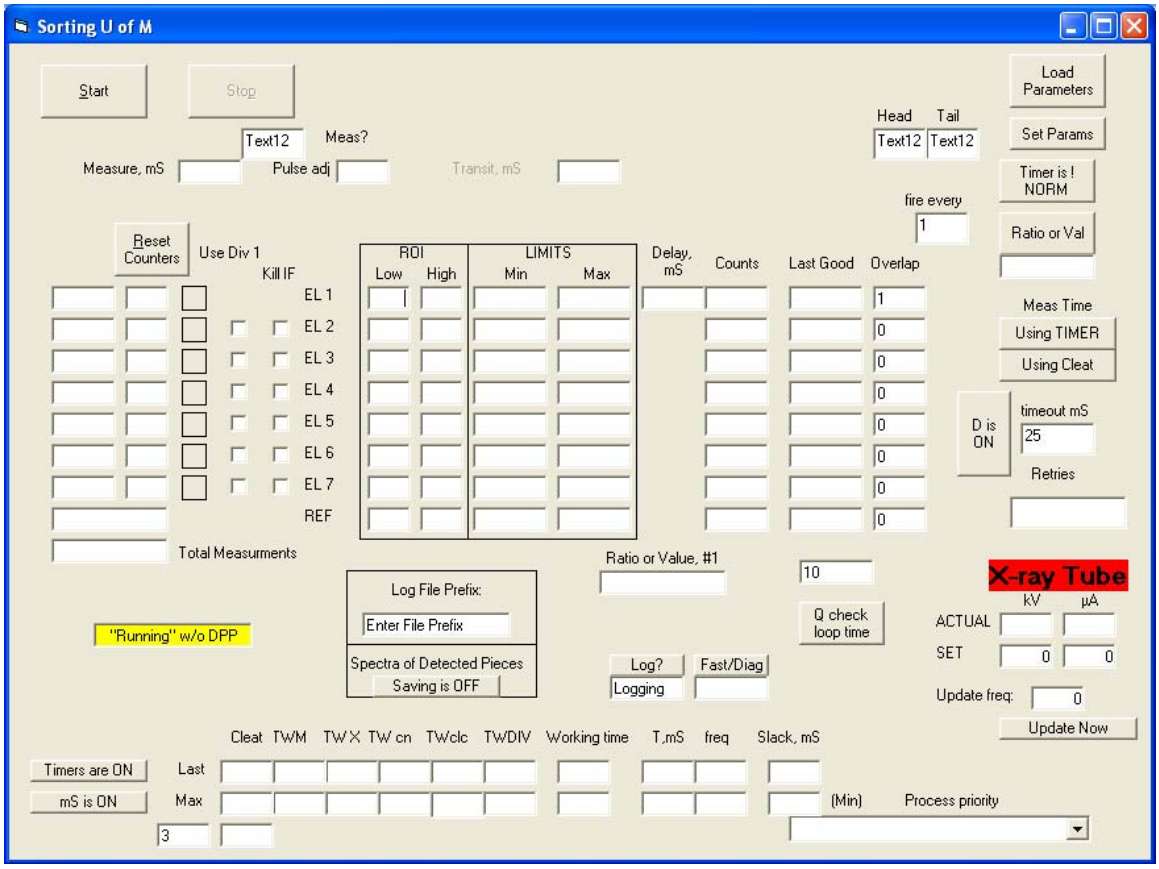
Operation

The timer should be running (circled 2). If not, see if the “**Resume MCA**” button (circled 4) is red. If so, click it.

If the “**Configure**” button (circled 1) is yellow, check that the parameters in the boxes match those shown below, and click the button.

To go the sorting screen click the “**SORT**” button (circled 3).

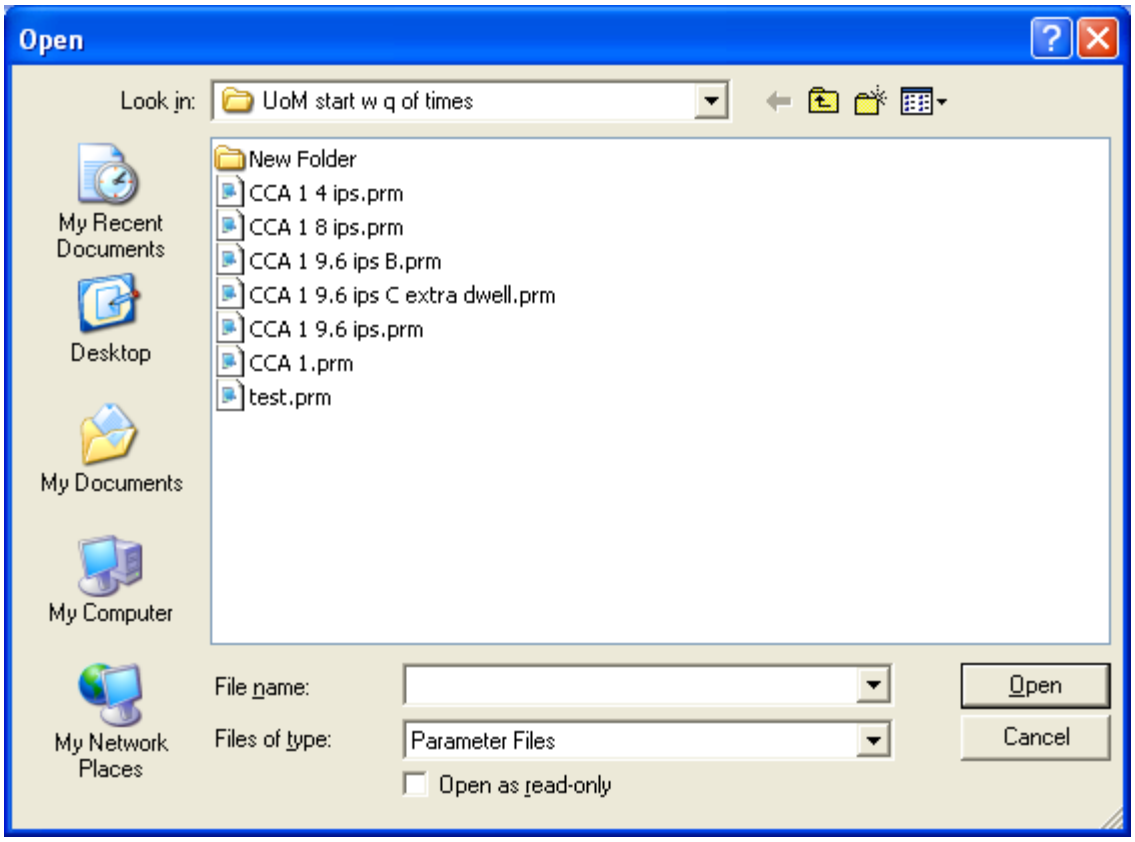




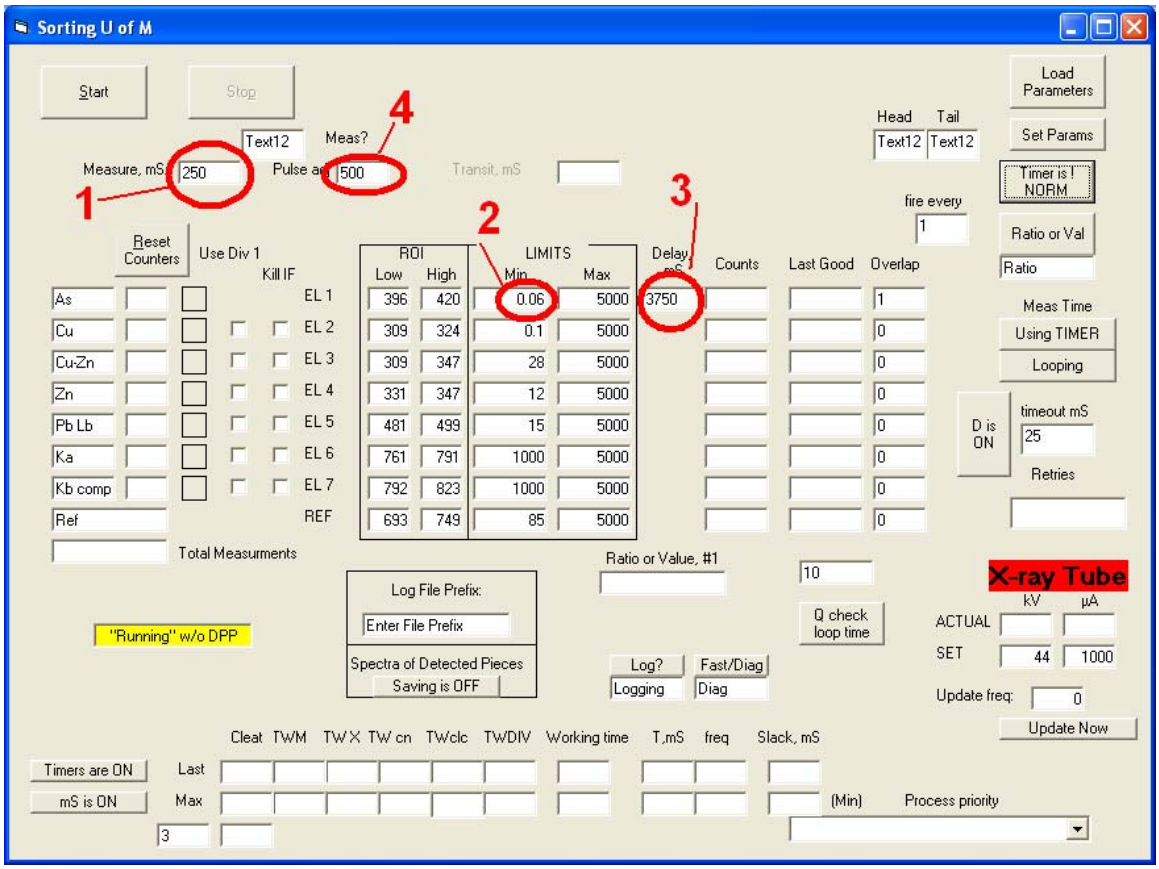
Sorting Screen

The important operations are “**Load Parameters**”, “**Start**”, and “**Stop**”.

Click the “**Load Parameters**” button to see a list of files that contain operating parameters and calibrations.



Double-click on one of the file names and the parameters will be loaded into the Sorting Screen. For example, the "**CCA 1 9.6 ips C extra dwell.prm**" file was used to load the values into this screen:



The main values in this screen are:

1: **Measurement adjust** time in milliseconds
2: Threshold for diversion. This is the arsenic count divided by the reference count.
3: **Delay** time in milliseconds. This is the time from the end of the detection of arsenic until the diverter raises.
4: **Pulse adjust**: Nominally, the diverter stays up for the amount of time that arsenic was detected. The “Pulse adjust” time is added to this dwell time for fine tuning. It can have a negative value.

To make changes in the values take effect, click the “**Set Params**” button. To make changes permanent, edit the “prm” file or create a new one.

Do not run the tube below 15 kV if the current is more than 500 microAmps.

The “**Start**” button will ramp up the X-ray tube over 10 seconds and will then start taking data.

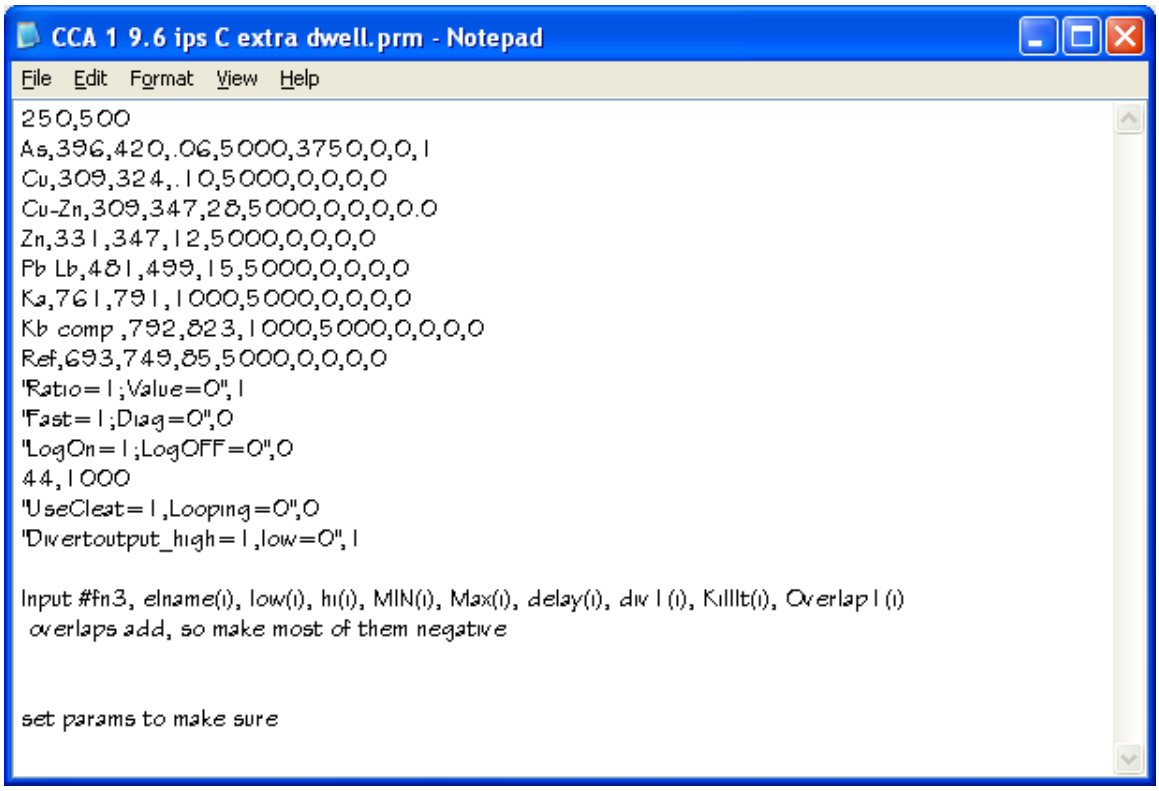
The “**Stop**” button will cause the analysis and diversions to stop, but will leave the X-ray tube on. To turn off the X-rays, press the green button on the electronics console or turn off the key switch.

Shutdown

Click the upper right red X box in the “Sorting” window and remove the key from the X-ray switch.

Parameter file

The file used in the example above is shown here:



The first row contains the measurement time and the pulse adjust time.

The next eight rows contain settings for each X-ray region measured

Name
Low channel of region of interest (ROI)
High channel of ROI
Threshold setting for diversion
Upper limit for diversion
Delay, milliseconds
Flag to use diverter if this element is found
Flag to prevent diversion if this element is found
Spectral overlap onto first element

The extension of these files must be ".prm" to be shown in the "Load Parameters" screen.

Troubleshooting

If the computer appears to start normally but the screen goes black after the initial Windows XP screen, press the Control, Alt, and F1 keys simultaneously for two seconds.

B. Tube Control

Note: do not run this program while the AAI6 UoM program is running as there will be hardware conflicts.

This program is used with the PX4 program to explore the effects of different tube settings and to set ROIs.

This program is also used to slowly ramp up the tube if it has been unused for long periods. See the MAINTENANCE section

Do not run the tube below 15 kV if the current is more than 500 microAmps.

Operation

Click the icon or the file name in the folder. Enable the X-ray tube by turning on the X-ray key and pressing the red button on the electronics console. Use the sliders or type in numbers in the lower boxes to set the tube high voltage and current.

Note: when the X-ray tube is disabled, small, but non-zero readings are normal.

C. PX4

Note: do not run this program while the AAI6 UoM program is running as there will be hardware conflicts.

Used to set electronic parameters and take spectra for configuring AAI program.

Operation

Resume MCA if needed by clicking on the red "**Resume MCA**" button.

In the "**Preset Time**" box, pull down the arrow to select 30 seconds then click on "**Configure**".

In the **Count Mode** box, select the "**Delta**" button.

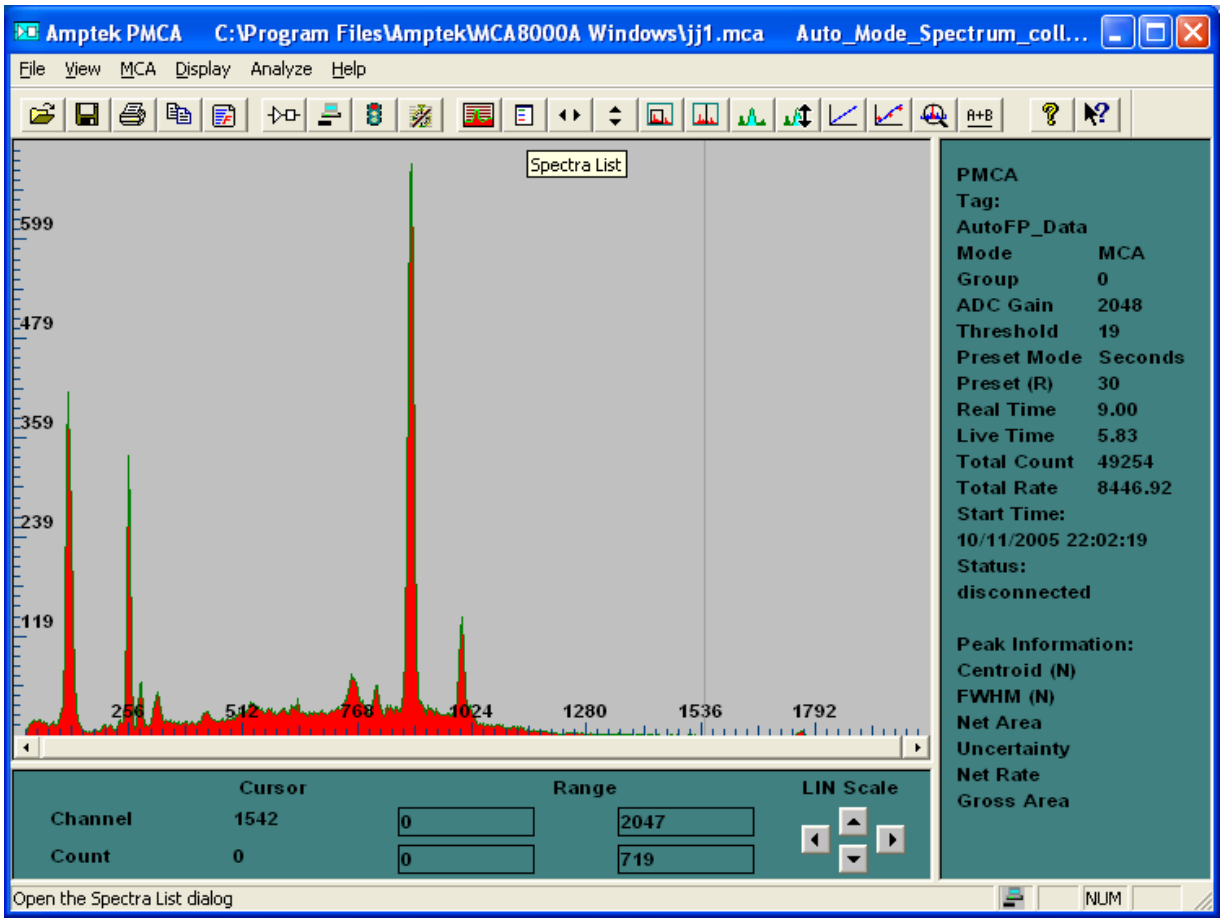
Click on "**Save Spectrum**" to save the data.

D. ADMCA

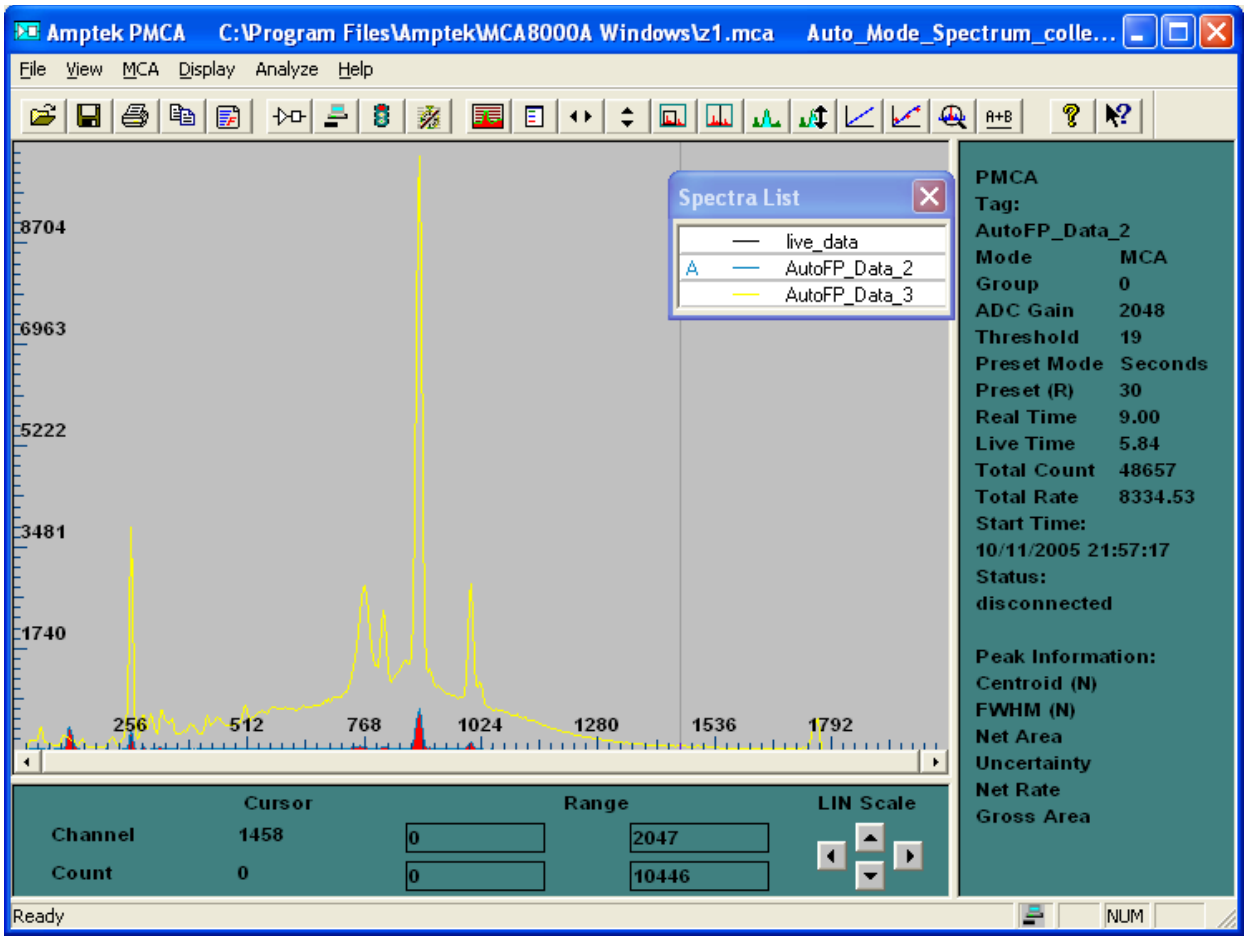
Used to display spectra from PX4, allows overlaying different spectra and makes some calculations.

File Open

Spectra List



Overlay Spectra with Spectra List


Amptek PMCA C:\Program Files\Amptek\MCA8000A Windows\z1.mca Auto_Mode_Spectrum_colle...
File View MCA Display Analyze Help
Spectra List
live_data
AutoFP_Data_2
AutoFP_Data_3
8704
6963
5222
3481
1740
256 512 768 1024 1280 1536 1792
PMCA
Tag:
AutoFP_Data_2
Mode MCA
Group 0
ADC Gain 2048
Threshold 19
Preset Mode Seconds
Preset (R) 30
Real Time 9.00
Live Time 5.84
Total Count 48657
Total Rate 8334.53
Start Time:
10/11/2005 21:57:17
Status:
disconnected
Peak Information:
Centroid (N)
FWHM (N)
Net Area
Uncertainty
Net Rate
Gross Area
Cursor
Range
LIN Scale
Channel 1458 0 2047
Count 0 0 10446
Ready
NUM

8. Safety

Keep all persons away from the QXR-W system during operation.

Operators should be educated in Radiation safety and aware of the hazards of X-ray exposure.

For your protection and to prevent damage to the QXR-W, do not attempt to disassemble or adjust the QXR-W unless authorized to do so.

X-ray beacons indicate when the X-ray tube is turned on. The beacons should be mounted so that they are visible from all directions.

Emergency OFF switches are provided in the case the QXR-W must be immediately turned off. The Emergency OFF switches stop the conveyors and turn off the X-ray tube. The Emergency OFF switches should be mounted where workers can push them easily.

The Emergency OFF buttons do not disable the diverter – its pneumatic piston can only be safely disabled by disengaging its air source.

The air supply can be interrupted by the red exhaust valve next to the regulator. The valve can be turned so it indicates “EXH”, and its dial allows it to be locked.

Turn the red exhaust valve to “EXH” when working near the diverter, and confirm that the diverter can move freely by pushing it from underneath. Avoid putting yourself or others in the way of the diverter.

The diverter can move automatically without warning. It can create a pinch point and/or a shear point.

Do not operate the diverter with supply pressure higher than 50 psi.

Remove the X-ray Enable key and push the Emergency OFF button before approaching the QXR-W system.

Do not turn the QXR-W system on when persons are in and/or around the QXR-W system.

The QXR-W optical assembly is housed in a shielded enclosure to ensure that X-rays are safely contained while in operation. The enclosure consists of steel panels and doors. The doors are equipped with safety switches that disable the X-ray circuitry. The non-removable panels are screwed on and bonded with a high strength epoxy. In the event that a door is opened while the power is on, the safety switch will disengage, turning the power off.

Do not disable the safety switches of the QXR-W system.

If any of the non-removable panels are removed or the high strength epoxy bonds are broken, the panels should be put back in their positions and fixed with high strength epoxy.

Leaded vinyl curtains must be properly positioned for X-ray shielding.

If the vinyl curtains are damaged they should be repaired and the system shielding should be checked by qualified personal.

Do not attempt to operate the system with any of the panels or leaded vinyl curtains removed or out of place, or doors not fastened.

The conveyors should be fastened to the ground and be stabilized against lateral loads such as wind and people moving on the conveyors.

The windows of the X-ray tube and detector are made of beryllium.

9. Maintenance

Check routinely

- The conveyor tie-downs while it is in the Test Area
- XRF box window film is secure and for dirt buildup
- Optical assembly fans are blowing and that the XRF box purge flow is adequate
- Conveyor belt tension, wear, and tracking
- Conveyor gear box lubricant at the manufacture's recommended interval
- The fasteners of the system – conveyors, diverter assembly, and enclosures.

X-ray Tube

If the tube has been unused for two weeks or more, start it slowly, with this schedule:

Run the "Tube Control" program.

a) Set the current to 0.

b) Set the voltage to 10 kV

c) Raise the current to 100 µA . Wait 5 minutes.

d) Raise the voltage to 20 kV. Wait 5 minutes.

e) Raise the voltage to 30 kV. Wait 5 minutes.

f) Raise the voltage to 40 kV. Wait 5 minutes.

g) Raise the current to 250 µA . Wait 5 minutes

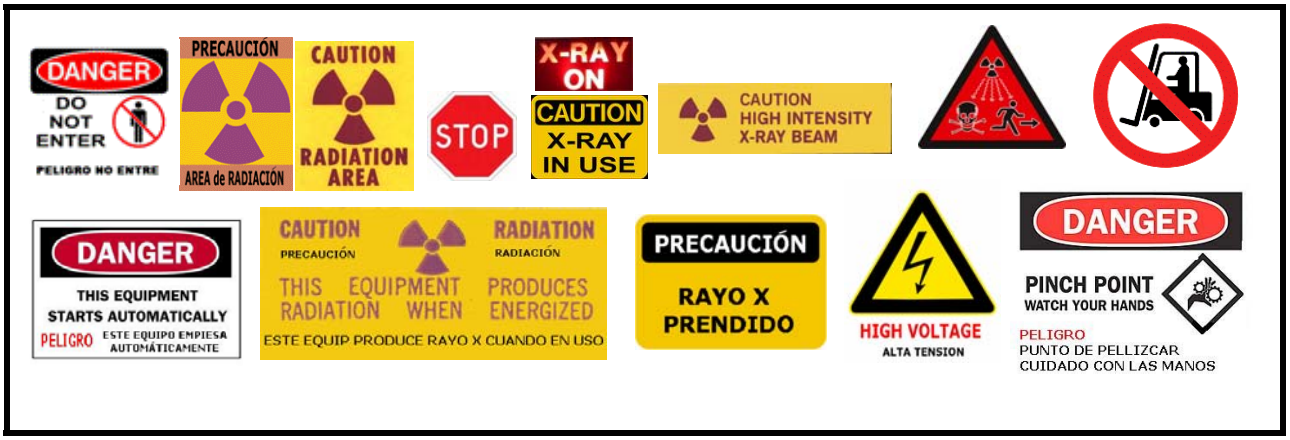
h) Wait 5 minutes, then increase current to 500 µA. Wait 5 minutes.

i) Raise the current to 1000 µA

Appendix B.7, FIELD SAFETY PRACTICIES

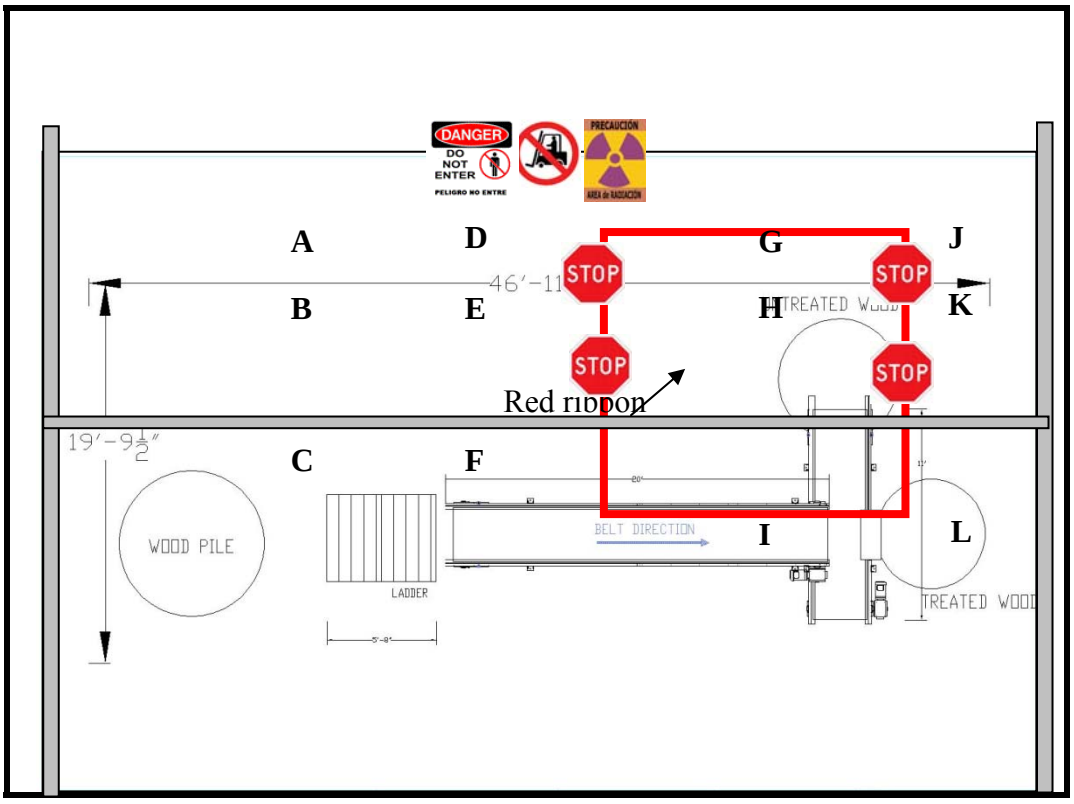
B.6.I Signage

A series of signs were used to enhance the safety at the site (Figure X). Three types of signs were used: warning for radiation, warning for high voltage, and warning for pnumatic movement. Most of the signs were illustrated in both English and Spanish. The following signes were used:



FigureX: Signs used at the site of the sorting system.

There is only one practical entrance to the area. A “Do not enter” sign, a “no forklift” sign, and a radiation warning sign were placed at the entrance. Red ribbon strips with “Danger” words were used to seprate the area below the XRF units to raise the awareness of the potential radiation. All other signs were placed around the red ribbon strips on the four poles that supported the roof, except for some radiation beam signs, which were placed on the XRF unit, right aside form the x-ray on light (Figures X and XX).



FigureX: Site layout and a sketch of the system with the red ribbons and signs.

FigureX: Safety Signs On Components of the System.

B.6.II Radiation Safety Check

Potential radiation leaks from the system was first checked by staff (Edward Pombier and John Owens) from the Radiation Control Center at the University of Miami. Two site visits were arranged, one on July 14, 2008 and another on July 28, 2008. Their measurements, including those with Ludlum Model 19, showed a dose rate level of 7 to 8 uR/hr, indicating no threat of radiation leakage.

In addition, we used our newly purchased Ludlum Model 19 to detect possile radiation leaks from the unit. Twelve spots were checked for background dose rate and dose rate when the XRF unit was on. Spots A, B, D, and F are four working areas when the system was on, and spot H was right below the XRF unit. The background dose rate was found to be between 4 to 7 μR/hr. The dose rate measured with the XRF unit on was within the same range (4 to 7 μR/hr) for all spots. The dose rates appeared to be higher close to the four big rocks (at D, G, F, and I) than the rest of the areas. The four rocks were used to stablize the whole unit. Measures at spot E at the conveyor level revealed a same level of dose rate. We thus did not detect any X-ray leakage.

All project participants were required to wear a radiation body badge and a ring badge. These badges have since been collected from the participants and have been submitted for measurements. Results from the radiation badges are pending.